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Left ventricular bands
A normal anatomical feature

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SUMMARY Discrete delicate fibromuscular structures crossing the cavity of the left ventricle were identified on morphological examination in 329 (48%) of 686 hearts from patients of all ages with congenital heart disease, acquired heart disease, or normal hearts. These structures were also present in 151 (95%) of 159 hearts from animals of six species. Cross sectional echocardiographic findings compatible with these structures were obtained in 39 (21·7%) of 179 children reviewed retrospectively and in three of 800 (0·4%) adults studied prospectively. These structures appear to be a normal anatomical finding.

Isolated examples of filaments of tissue crossing the cavity of the left ventricle were first reported in 1893 by Turner.[1–3] In 1906 Keith and Flack noted that they were almost constantly present in both bovine and human hearts and they regarded them as being part of the left bundle branch distribution of the Purkinje conduction fibres.[4] Although these structures are hardly mentioned in the standard textbooks of anatomy and cardiac pathology,[5 6] the development of echocardiography appears to have reawakened interest in them.[7–11]

We made a quantitative morphological assessment of the prevalence of these structures as this would seem to be a prerequisite for an appraisal of their importance. For reasons that we will discuss later we have called these structures left ventricular bands.

Patients and methods

We reviewed 686 hearts in the collection of this hospital specifically for the presence of left ventricular bands. Six hundred and thirty six were from children below the age of 15. Of these, 581 had had congenital cardiac malformations and 55 had had normal hearts. The 50 other hearts were from adults who had previously had surgery for acquired cardiac disease. We also examined 159 hearts from six species of animals (none of which was killed for the purpose of the study). Ventricular bands were identified as discrete fibromuscular structures crossing the left ventricular cavity and having no attachment to the atrioventricular valve (Fig. 1). They extended from a papillary muscle to the septum, from a papillary muscle to the free wall, between the papillary muscles, or from the septum to the free wall. They were either single or multiple and sometimes branched. Small multiple strands at the junction of the setpum with the free walls were disregarded as were small apical networks.

In addition to the morphological study, we reviewed cross sectional echocardiograms from 800 adults and 179 children. Adult echocardiograms had been recorded on a Varian V3400 phased array system with a 2·2 MHz transducer. The children had been examined with a mechanical sector scanner of either 5 or 3·5 MHz frequency, on a Xonics 5210 or an Advanced Technology Laboratory system. Echocardiograms in adults were reviewed by FE and those in children by NW. A ventricular band was deemed present if a consistent linear echo dense structure was seen crossing the left ventricle. We did not consider it to be necessary to have evidence of the band in two different echocardiographic sections for the same patient, though bands were seen occasionally in two planes in the children.

Results

MORPHOLOGICAL FINDINGS

Left ventricular bands were present in 303 of the 636 (47·6%) children's hearts. There was no appreciable

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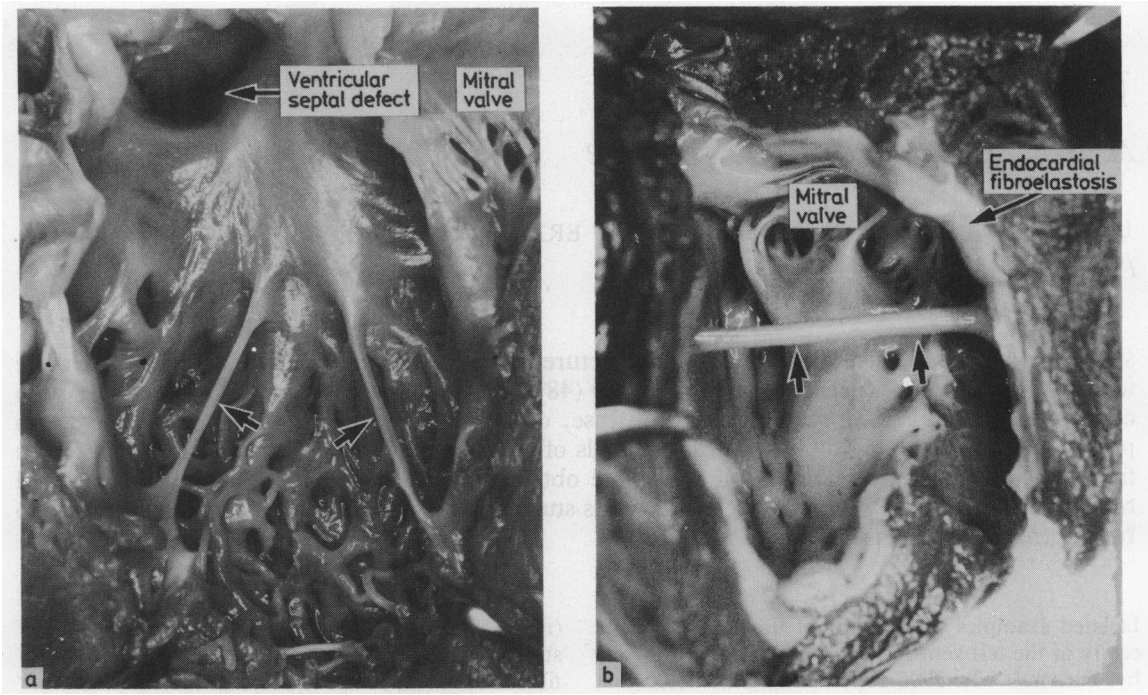

Fig. 1 *Left ventricular bands in children with congenital cardiac malformation. (a) Two oblique bands in a 3 week old boy who had d-loop transposition of the great arteries and a high ventricular septal defect. (b) Greatly thickened transverse band in a 2 day old boy with appreciable endocardial fibroelastosis and a stenosed, thickened, bicuspid aortic valve.*

difference in the prevalence of the bands between normal hearts (25, 46%) and congenitally malformed hearts (278, 47·8%) or between boys (351, 47%) and girls (113, 49·3%). Prevalence increased significantly with age, and in children over 1 year left ventricular bands were present in 114 (67%) of the hearts examined (Table 1).

The prevalence of bands associated with different types of congenital malformation showed a division into two groups (Table 2). Ventricular bands were present in 17 (68%) and 62 (66%) of hearts with isolated ventricular septal defects or tetralogy of Fallot respectively. This was roughly twice the prevalence in hearts with transposition of the great arteries, anomalous pulmonary venous connexion, left heart hypoplasia, or right heart hypoplasia (Table 2). This was probably related to the longer survival of patients with either isolated ventricular septal defects or tetralogy of Fallot.

Three hundred and sixty three bands were recorded

Table 1 *Prevalence of left ventricular bands in children*

Age (months)	*No of patients*	*No (%) with bands*	*Difference (%)*	*Standard error of difference (%)*
		*Morphological series**		
0–3	343	128 (37)	17	5·5
3–12	104	56 (54)		
>12	170	114 (67)	13	6·1
Unknown	19	5		
Total	636	303 (48)		
		Echocardiographic series†		
0–3	48	10 (21)	8	9·5
3–12	42	12 (29)		
>12	89	17 (19)	10	10·2
Total	179	39 (22)		

*χ^2=42·23; n=2; p<0·001.
†χ^2=1·67; n=2; p=0·3<0·5 (not significant).

Table 2 *Prevalence of left ventricular bands in children with various forms of congenital cardiac malformation*

Cardiac malformation	*Morphological series*		*Echocardiographic series*	
	No of children	*No (%) with bands*	*No of children*	*No (%) with bands*
Isolated ventricular septal defect	25	17 (68)	49	14 (28)
Tetralogy of Fallot	94	62 (66)	12	3 (25)
d-loop transposition	112	40 (36)	18	
Anomalous pulmonary venous connexion	42	14 (33)	1	
Left heart hypoplasia	93	28 (30)	2	
Right heart hypoplasia	41	12 (29)		
Other	174	104 (60)	67	15 (22)
All congenitally malformed hearts	581	278 (48)	149	32 (21·5)
Normal heart	55	25 (46)	30	7 (23)
Total	636	303 (48%)	179	39 (22)

in the 303 children. Almost all of these were attached to the septum, with the posterior papillary muscle being the most common site of peripheral attachment. Table 3 shows sites of attachment of the bands. More than one band was present in roughly 20% of the positive cases. Bands were present in 26 (52%) of the adult hearts. The age of the patients from whom the hearts with bands had been taken varied from 19 to 77 years (median 47 (mean 45·8) years), and that of the patients from whom hearts without bands had been taken from 20 to 60 years (51 (49)). The prevalence of bands was significantly higher in men (25 (58%) of 43 men's hearts had bands) than in women (one (14·3%) of seven women's hearts had bands) (difference 43·7%, standard error of difference 15·2%).

The anatomical distribution in adult's hearts was similar to that found in the children's hearts (Table 3). We noted that in those patients with hearts showing endocardial thickening due to congenital or acquired disease the ventricular bands were generally thickened also (Fig 1). Some ruptured bands were seen (Fig. 2).

Left ventricular bands were seen in most of the animal hearts. They were present in all 42 sheep, 20 horses, 24 cats, and 12 dogs examined, in 23 of 25 (92%) oxen, and in 31 of 36 (86%) pigs. The overall prevalence in animals was 132 out of 139 (95%). The appearance of the bands varied between species but within each species the pattern was fairly constant, and the species could often be recognised by the internal configuration of the left ventricular bands (Table 4, Fig. 3).

ECHOCARDIOGRAPIC FINDINGS

In children discrete, linear, echo dense structures were identified retrospectively in 39 of 179 (21·7%) cross sectional echocardiograms that had been performed by several different operators who were not specifically searching for these structures. In the light of our morphological findings we thought that these echoes were produced by ventricular bands. Echoes of this sort were seen most often in the left parasternal long axis and apical four chamber planes. The patients who yielded positive images were aged from 1

Table 3 *Attachments of left ventricular bands in 686 human hearts studied morphologically*

	*No (%) of bands in children**		*No (%) of bands in adults†*	
Septum to posterior papillary muscle		190 (52)		21 (58)
Septum to anterior papillary muscle		14 (4)		3 (8)
Septum to posterior free wall	82		2	
Septum to anterior free wall	61	152 (42)	7	9 (25)
Septum to both free walls	9			
Anterior to posterior free walls		7 (2)		1 (3)
Anterior to posterior papillary muscle				2 (5·5)
Total		363		36

*Altogether 363 bands present in hearts of 303 (48%) of 636 children.
†Altogether 36 bands present in hearts of 26 (52%) of 50 adults.

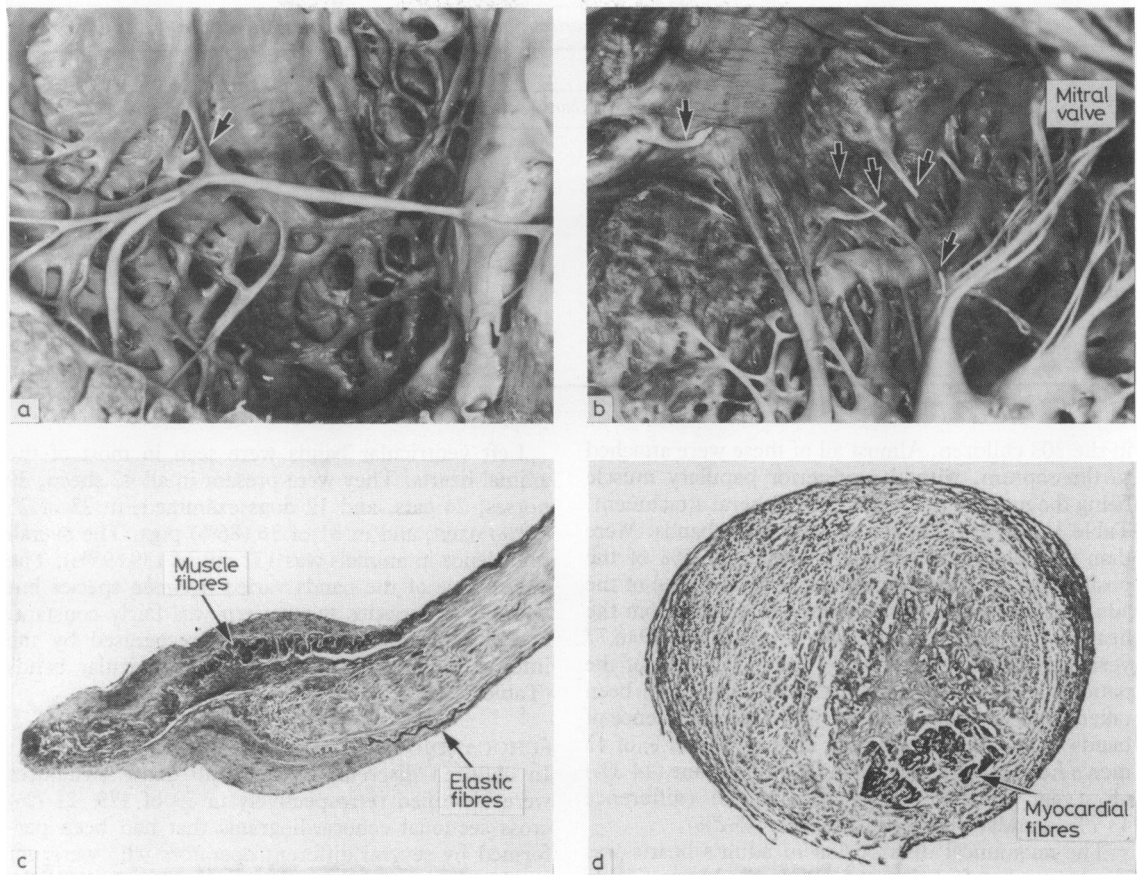

Fig. 2 *Left ventricular bands in adults. (a) Branching band (arrow) in a 48 year old man with old rheumatic aortic valve stenosis. (b) Several broken bands (arrows) in a 50 year old woman with rheumatic mitral and aortic valve stenosis. The one on the left, with the bulbous tip and the one in the centre, with the tapering tip, appear to be remnants of a single band that had undergone rupture before death. (c) Histological longitudinal section of the bulbous tip seen above (top right), showing the fibrous structure with elastic fibres and muscle fibres. The free extremity is smoothly rounded. (Haematoxylin and eosin stain × 16.) (d) Histological transverse section of another band from the same patient, showing the small core of myocardial fibres. (Haematoxylin and eosin stain × 64.)*

Table 4 *Attachments of left ventricular bands in hearts from 42 sheep, 31 (86%) of 36 pigs, 23 (92%) of 25 oxen, 24 cats, 12 dogs, and 20 horses*

*Attachment of left ventricular bands**	*No (%) of bands in†*					
	Sheep	*Pigs*	*Oxen*	*Cats*	*Dogs*	*Horses*
Septum to posterior papillary muscle	3 (6%)	8 (25%)	3 (10%)	7 (27%)	6 (50%)	
Septum to anterior papillary muscle	3 (6%)	2 (6%)	12 (41%)	2 (8%)	1 (8%)	
Septum to both papillary muscles	33 (69%)	21 (61%)	7 (24%)	14 (54%)	5 (42%)	20 (100%)
Interpapillary	8 (17%)					
Apical		1 (3%)	7 (24%)	3 (11%)		
Anterior to posterior	1 (2%)	1 (3%)				
Total	48	33	29	26	12	20

*In many hearts there was more than one type of band.
†Altogether 159 bands present in hearts of 152 (95%) of 159 animals.

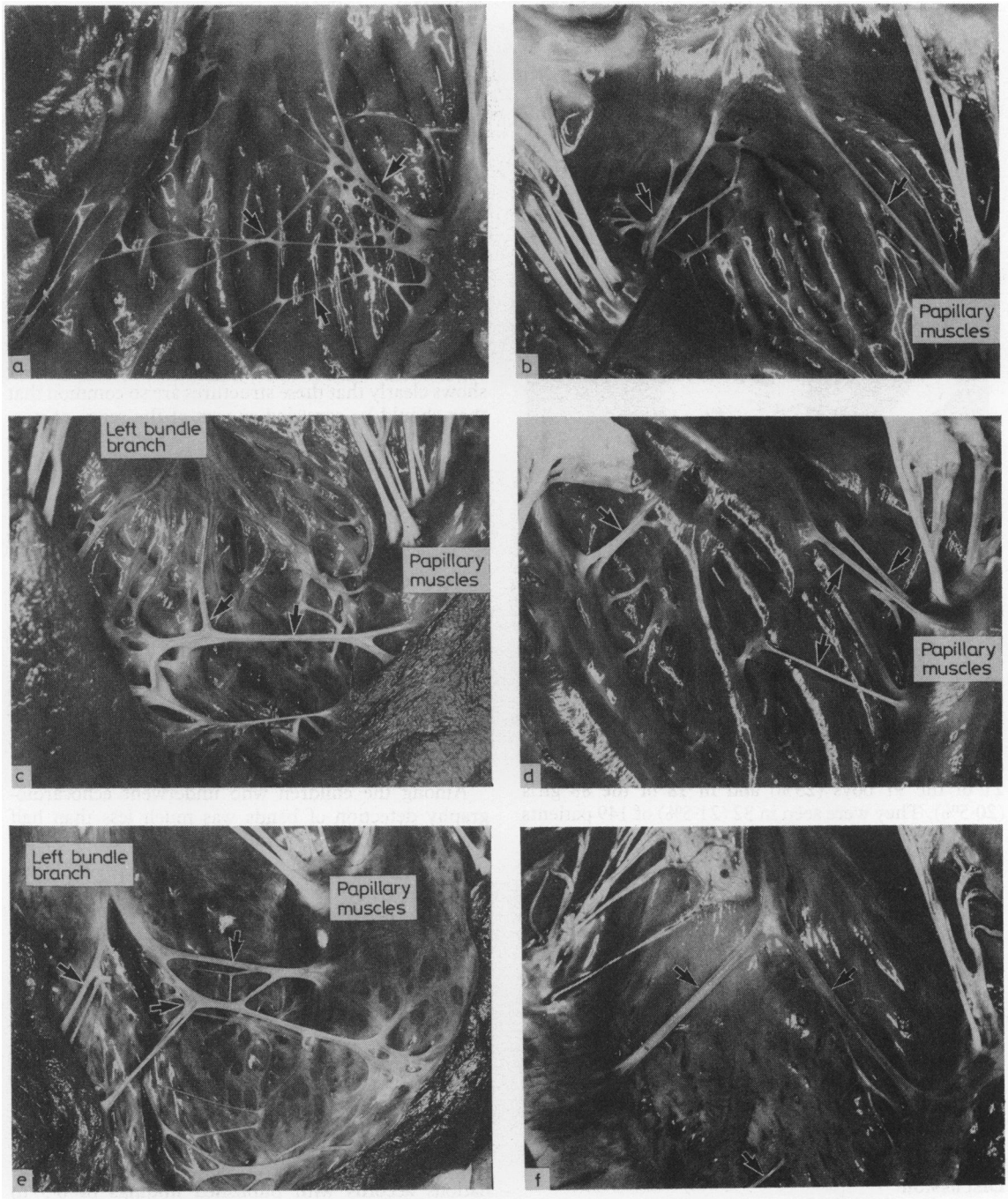

Fig. 3 *Left ventricular bands in some other mammals. (a) Complex branching network in apical half of the ventricle in a cat. (b) Straight strands and branching bands in the basal half of the ventricle of a dog. (c) Branching band towards the apex in a sheep. Left bundle branch is clearly visible and continues into band. (d) Several discrete bands attached to papillary muscles in a pig. (e) Branching and single apical bands in continuity with the left bundle branch in an ox. (f) Discrete bands passing from central region of septum and a smaller one near apex in a horse.*

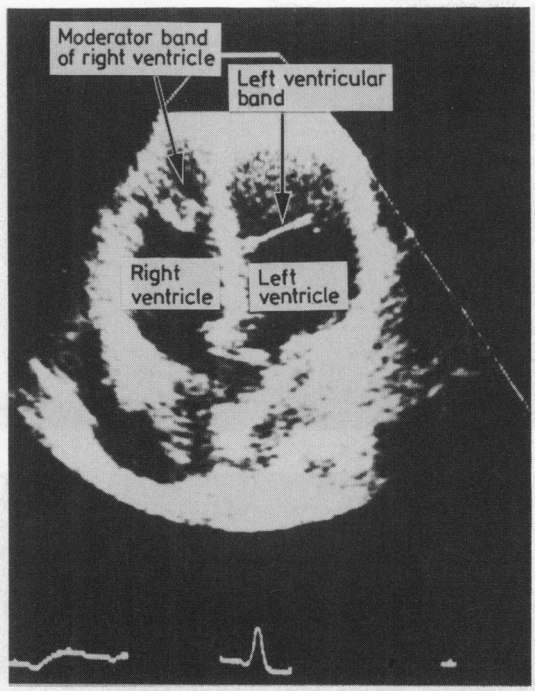

Fig. 4 *Cross sectional echocardiogram, long axis view, from a 19 year old man with aortic stenosis.*

week to 18 years (median 10 months) and those who yielded negative images were 1 week to 14 years (median 8 months) (Table 1). Bands were present in 21 of the 91 boys (23%) and in 18 of the 88 girls (20·5%). They were seen in 32 (21·5%) of 149 patients with congenital cardiac malformation and in seven (23%) of the 30 with normal hearts. None of the above comparisons showed any significant difference. There were 61 cases of isolated ventricular septal defect or tetralogy of Fallot. Seventeen (28%) of the children affected showed left ventricular bands compared with 15 (17%) of the 88 with other cardiac malformations, but this difference was not significant (difference 11%, standard error of difference 7%).

In 800 cross sectional echocardiograms in adult patients left ventricular bands were seen in only three cases (0·375%). These examinations were studies in which left ventricular bands were specifically sought at the time of the initial echocardiogram.

Discussion

Various different terms have been used to describe what we have chosen to call left ventricular bands. These terms include: aberrant left ventricular chordae or cords[10 12]; anomalous left ventricular chordae tendinae[8 13]; cords or tendinal cords[5 12 13]; false chordae[6]; false tendons[5 7 9 11 14]; muscular strands[15]; anomalous left ventricular bands[12]; moderator bands[1-4 16 17]; septomarginal trabeculae[18]; and telegraph wires.[19] Although many of the bands bear some similarity to mitral valve chordae tendinae and probably have a similar mode of embryological origin, by delamination from the inner aspect of the ventricular wall, in many cases they are not connected with the papillary muscles. Furthermore, they do not always contain muscle fibres. The use of the terms chordae (or chords), tendons, or muscular strands is therefore inaccurate and misleading. The use of the term "moderator band" may lead to confusion with the right ventricular structure of that name, and the epithet "anomalous" is not appropriate as this study shows clearly that these structures are so common that they should be regarded as part of the range of normality rather than as deviations. We therefore prefer to use the non-committal term of left ventricular bands.

Bands were present in about half of the human hearts examined and were present at all ages. The increase in prevalence in older children was possibly associated with easier visibility of the delicate bands in the larger hearts and the higher prevalence in some types of congenitally malformed hearts may also be related to longer survival and larger hearts.

The high prevalence in animals should be noted. Bands have previously been described in dogs,[15] from which they are obtained as a convenient source of Purkinje fibres for experimental purposes.[14] They have also been noted in cats[17] and horses.[18]

Among the children who underwent echocardiography detection of bands was much less than half that in the morphological series (39 (22%) *v* 303 (48%)). This prevalence was considerably greater than that of any previously reported series. Perry *et al* found 31 examples in 3847 consecutive cross sectional echocardiograms in children aged from 1 day to 15 years, a prevalence of only 0·8%.[9]

The incidence of echocardiographic detection in adults was very low in comparison with the prevalence on morphological examination and with the echocardiographic findings in children. This was at least in part due to the improvement in image quality of the newer echocardiographical instruments and to the better resolution of the higher frequency transducers used for paediatric imaging. Our findings of bands in three (0·375%) of 800 adult echocardiographic examinations accords with published findings of 0·5 to 4%.[7 10 11]

In a few recorded instances left ventricular bands have been thought to be associated with clinical cardiac signs such as formation of thrombus,[5] murmurs,[9 12] pre-excitation,[13] rate dependent premature

ventricular contraction,[9] and cardiac failure (in cats).[17] Vered *et al*, however, did not find any correlation between clinical features and the echocardiographic visualisation of left ventricular bands in 42 patients among a total of 2079.[11] Our study shows clearly that left ventricular bands are common and might therefore, by chance alone, be associated with almost any physical sign or symptom. We doubt whether they have any clinical importance, with the possible exception of their suggested role as a source of innocent systolic murmurs.[9 12]

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